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PHYSICS AT THE DETROIT MEETING OF  
THE AMERICAN ASSOCIATION FOR THE  
ADVANCEMENT OF SCIENCE.

SECTION B of the American Association for the Advancement of Science met with Professor Carl Barus in the chair and Professor Frederick Bedell as Secretary. 'Long Range Temperature and Pressure Variables in Physics' was the subject of Professor Barus's vice-presidential address, which has been published in full in SCIENCE. It was very interesting and was very well received. The address dealt with the historical development of pyrometry and piezometry, with a view to the present state of progress in these subjects, and with especial reference to their application to problems on the physics of the earth's crust.

The first paper on the list was by Professor F. P. Whitman and Miss Mary C. Noyes on the effect of heat on the elastic limit of copper wire. Their work was a continuation of a research on the effect of heat on Young's modulus (published in the *Physical Review*, Vol. II., p. 277). The yield-point was found to increase as the wires were stretched, heated and cooled. From a long series of tests made on the same wire it appeared that the wire was approaching a permanent condition. If the wire was heated to a red heat, or if it was stretched considerably beyond its elastic limit at the start, it maintained a nearly constant state afterwards. There were curves shown which graphically represented the changes in the behavior of the wire.

Professor A. L. Foley next read a paper on 'Arc Spectra.' He examined the light coming from the arc and found that it was due to concentric layers of different color. He used a concave grating to throw the spectra of different parts of the arc upon photographic plates. The outer layer was found to be strongest in the yellow. The upper carbon, whether positive or negative, was covered to a greater depth with

the yellow flame. Inside the yellow was a blue area stronger at the positive carbon, and inside the blue and at the positive carbon violet was found.

Mr. Chas. F. Brush read a notable paper on the transmission of radiant heat by gases at varying pressures. Before describing his own investigations he referred briefly to those of Dulong and Petit, who used a large copper 'balloon,' about three decimeters in diameter, coated with lamp-black on the inside, in the center of which the thermometer bulb was placed. In discussing the cooling of bodies *in vacuo* Dulong and Petit fell into the grave error of deducing the behavior of the last few millimeters of gas from that of the rest. In this way they arrived at their 'Sixth Law:' The cooling power of a fluid diminishes in a geometrical progression when its tension itself diminishes in a geometrical progression. If the ratio of this second progression is 2, that of the first is 1.366 for air, etc. Mr. Brush said that his own observations show that this law can be approximately true only in the case of a large balloon, and at pressures from a few millimeters upward; that there is no suggestion of it where a small balloon is used, and at small pressures it does not obtain with either large or small balloons; he found that in a small balloon the cooling effect of the last millimeter of air is nearly ten times as great as that of all the rest, up to atmospheric pressure, combined. It was through misplaced confidence that Dulong and Petit were led to place a value on the rate of cooling *in vacuo*, something like a hundred per cent. too high; and as they derived the cooling values of gases by deducting the cooling effect of a vacuum from the total, all their values for gases are much too low. This error vitiates much of their other work. Mr. Brush carried his observations down to those made at one-twentieth of a millionth

of an atmosphere and found that the rate of cooling did not break down materially even then. To measure pressures he constructed two McLeod gauges. These gauges and their use Mr. Brush described in another paper on the measurements of small gaseous pressures. He gave, as an example of the delicacy with which small pressures were measured, the measurement of about two millionths of atmospheric pressure, with a probable error of only one part in three thousand of the quantity measured. From this he concluded that, with the apparatus described, small gaseous pressures might be easily measured with a probable error of less than a thousandth part of the millionth of an atmosphere. Mr. Brush showed many figures and curves to illustrate his work.

Professor W. A. Rogers read a paper on a final determination of the relative lengths of the imperial yard of Great Britain and the meter of the archives.

Professor Nichols read Mr. S. G. Barnett's paper on the influence of time and temperature upon the absolute rigidity of quartz fibres. Mr. Barnett found no time effect even after three months and an exceedingly small positive temperature coefficient of about three ten-millionths.

The discharge of electrified bodies by X-rays, by Dr. C. D. Child, was a subject which has been interesting scientific circles of late. The air, and in fact almost every gas, is an excellent insulator under ordinary conditions; but when acted upon by X-rays it becomes for the time a conductor. The resistance offered to the passage of electricity under these circumstances depends upon the pressure, temperature and kind of gas, as well as upon other more obscure causes. Dr. Child's paper deals especially with the influence of the *pressure* of the gas. He finds that, when the pressure of the air is increased from a few millimeters of mercury up to atmospheric pressure, the rate at which electricity can be conducted by

the air in general increases to a maximum and then decreases again. The pressure at which the conductivity of the air is greatest depends upon the E. M. F. tending to send current through it. If the E. M. F. is high the pressure for maximum conductivity seems to be greatly in excess of atmospheric pressure and lies beyond the range of Dr. Child's measurements.

In addition to a careful study of the effect of pressure upon the phenomena, Dr. Child has also investigated several other points, some of which have heretofore been in dispute. For instance, he finds that electricity can be continuously discharged from a charged body under the influence of X-rays, even when the body is covered with a *solid* insulator, such as a thin layer of paraffin. This result agrees with the observations of Professor J. J. Thomson and contradicts in part the conclusions of Lord Kelvin. Dr. Child has also studied the effect of X-rays developed by an induction coil when the rate of interruption is varied. Many parts of Dr. Child's work which cannot even be referred to here will go far toward explaining the irregular and contradictory results which most observers in this line have heretofore obtained.

Professor F. P. Whitman described some investigations which he had made on the brightness of pigmented surfaces under various sources of illumination. The colors of the surfaces were ten in number, ranging through the spectrum. The flicker photometer was used for the comparisons, and some very interesting information was obtained.

Professor H. S. Carhart read a paper on the design, construction and test of a 1,250 watt transformer which had been made under his directions by two of his students. The core type was chosen instead of the shell, for reasons of convenience, as the iron for the core could be cut at the tinsmith's without a die. From the data obtained in

its test it appeared that the transformer agreed in resistance, regulation and efficiency almost exactly with the values computed in advance. The fall in E. M. F. between no load and full load was 2.3 per cent., and the efficiency at full load was 95.4 per cent. This paper is published in the *Electrical World* for September 18, 1897. Dr. Karl E. Guthe described some experiments on the electrolytic action of condensers. He used commercial condensers, and found polarization and recovery much as in an electrolytic cell. He showed several curves illustrating the results obtained. The graphical treatment of alternating currents in branch circuits in cases of variable frequency, by Professor H. T. Eddy, was a very full exposition of the subject. Many diagrams were shown, in which a whole series of assumptions as to the capacity and self-induction gave a corresponding series of curves. It would not be possible to give a proper notice of Professor Eddy's paper without reproducing many of his diagrams.

Professor Alexander Macfarlane read an instructive paper on simple non-alternating currents. Professor A. G. Greenhill, of Woolwich, England, exhibited stereoscopic views of spherical catenaries and gyroscopic curves which were very interesting. The mathematics of each curve were given on the back of the card on which the stereoscopic projections of the curve were drawn. Professor Ernest Merritt read Dr. L. A. Bauer's paper on the magnetic survey of Maryland.

Professors G. S. Moler and Frederick Bedell exhibited apparatus adapted to determining the frequency of an alternating current. The instruments here included are two in number. The first one, which has already been described by George S. Moler (*Physical Review*, March-April, 1897), consists of a small synchronous motor brought to speed by a crank handle connected with the motor by a suitable train of

gears. The apparatus contains an electrically operated speed counter, so arranged that its reading gives the exact value of the frequency of the alternating current with which the synchronous motor is supplied. The whole apparatus does not weigh over nine pounds. The reading is correct to within .05 of an alternation. The second instrument consists of a sonometer or monochord. The alternating current flows through a piano wire mounted upon a sounding board. The wire passes between the poles of a permanent magnet. By means of a sliding bridge the period of the wire may be made equal to that of the alternating current. This is indicated by the vibration of the wire. A scale is arranged so that the position of the bridge indicates the frequency directly.

Dr. W. J. Humphreys gave an interesting account of some experiments on the effect of pressure on the wave-lengths of the lines of the emission spectra of the elements. He found a shift of the lines toward the red about proportional to the pressure and to the wave-length. The shift appeared to be independent of the temperature. Professor C. L. Norton described a new form of coal calorimeter. An abstract of his paper is in the *Electrical Engineer* of September 9, 1897. The coal is burned with oxygen inside the calorimeter in a platinum crucible, on a very thin dish of platinum perforated with a large number of holes near the edge. The lightness and good conducting power of the platinum crucible and plate assure their being at a high temperature during combustion, and to this is due the completeness of combustion. No trace of carbon monoxide and no indication of soot is to be found in the resulting gases. Professor E. B. Rosa read Dr. F. A. Laws' paper on a new form of harmonic analyzer. An electro-dynamometer was used. A current sinusoidal in character, and of frequency vari-

able in multiples of the main current, was sent through the fixed coil, and the main current through the other coil. The deflection of the electro-dynamometer gave means of computing the magnitude and phase of the different components.

Very interesting papers were read by Dr. N. E. Dorsey, on the determination of surface tension of water and of certain aqueous solutions by the method of ripples; by Professor Frank E. Bigelow, on the series of international cloud observations made by the United States Weather Bureau; by Professor C. F. Marvin, on kites and their use by the Weather Bureau in the exploration of the upper air, and by Mr. B. B. Brackett, on the effects of tension and quality of the metal upon the changes in length produced in iron wire by magnetization.

Professors E. W. Morley and D. C. Miller presented a joint paper on the coefficient of expansion of certain gases. As the coefficient of expansion of hydrogen has been determined by the International Bureau of Weights and Measures at Paris, with a very high degree of precision, that of other gases may be determined by comparison. The method used in these experiments is a differential one, in which the difference in the expansion of oxygen and hydrogen, for example, can be determined with accuracy. Hydrogen is placed in one globe of five liters capacity and oxygen in a similar globe. These globes are connected to a manometer. They are first surrounded with melting ice, and then with steam. The differential expansions are readily observed. In this way the coefficients of expansion of four gases have so far been determined as follows:

Carbon Dioxide.....	0.0037122
Nitrogen.....	0.0036718
Air.....	0.0036719
Oxygen.....	0.0036729

A Note on the Construction of a Sensitive

Radiometer was read by Professor Ernst Fox Nichols. In this paper the construction of a new form of compensating torsion radiometer, used recently in a number of researches in the remote infra-red spectrum, was described in detail. The instrument is capable of a higher degree of sensitiveness than either the spectro-bolometer or linear thermopile. A steadiness of action and freedom from extraneous disturbances, when working at high sensitiveness, are secured by means of the compensating action of two precisely equal vanes symmetrically mounted on either side of the axis of a quartz fibre suspension. The system, in consequence, is acted upon differentially by all accidental disturbances, while rays to be measured are concentrated upon one of the vanes. The degree of sensitiveness actually attained in one instance was so great that the influence of rays from a single candle at a distance of one-third of a mile could be detected and roughly measured. With an instrument of this kind Professors Rubens and Nichols have recently discovered heat waves one-fortieth millimeter in length, and have demonstrated their electro-magnetic character.

Professors E. L. Nichols and E. Merritt presented a paper on the photograph of manometric flames. The photographs were taken on a revolving drum of sensitized film, and showed in a striking way the effects of various sounds. Words and short phrases were spoken before the receiver. It was of interest to note that the effects of nearly like sounds could be distinguished in the photographs. The paper was illustrated with many lantern slides.

Professor Carl Barus read papers on the rate at which hot glass absorbs superheated water, and on a method of obtaining capillary canals of specified diameters. In the former he computed from experiment that there is an absorption per hour of 0.025 cm.<sup>3</sup> of liquid water per cm.<sup>2</sup> of glass sur-

face at 180°C. The importance of the observed increase in compressibility and in volume contraction in the lapse of time was especially dwelt upon. In the latter paper he said that elastic tubing punctured with 5,000 to 10,000 extremely small holes was subjected to external and internal pressure. The mean diameter of the pores in any given case is computed from the pressure-difference just necessary to cause a flow of gas against the capillary reaction of the wet porous septum. The author points out various applications of such tubes. Among other points, the cyclic character of the flows of liquid through the pores, when pressure increases and decreases consecutively, is exhibited.

Professor Frederick Bedell read a paper written by himself, Professor R. E. Chandler and Mr. R. H. Sherwood, Jr., on the predetermination of transformer regulation. To determine the regulation by this method a wattmeter, ammeter and voltmeter are located in the primary circuit. One set of readings is taken with the secondary short-circuited by a stout copper wire, the primary voltage being adjusted until the normal full-load current or any desired fraction of it flows in the transformer. No other data for obtaining a complete regulation curve is required except the one set of readings above mentioned and the magnetizing current. If a wattmeter reading is taken when the magnetizing current is measured, the data is sufficient to plot a complete efficiency curve as well as a curve for the regulation of the transformer. The two sets of measurements then consist of the reading of a wattmeter, voltmeter and ammeter, first on short-circuit with normal current, and second on open-circuit at normal voltage. The wattmeter reading in the first case gives the copper losses; in the second case, the core losses. It is commonly convenient to use the high-potential coil as primary in the short-circuit meas-

urements, and the low-potential coil as primary in the open-circuit measurements. A high-potential supply is not then needed, and as no power is required except to supply the losses, the complete test of a transformer may be made with an incandescent lighting circuit for the source of supply, a 50 light transformer being tested from one 16 c. p. lamp socket. The total drop is found by laying off in the proper manner the inductive drop, the magnetic leakage drop and the drop due to ohmic resistance. The method is theoretically an almost exact one. Practically it is an exact method and less likely to error than the ordinary method of determining the regulation of a transformer by loading it. The results given in this paper (given in full in *The Electrical World*), from a long series of tests on seven transformers of various makes, shows the reliability of the method, the secondary voltage at full load determined by it varying usually less than one or two-tenths of a volt from the voltage as found by measurement on the transformer when actually loaded. An approximate method (by Kapp) used by one of our large electrical companies gives less accurate results. The reader is referred to the data given in the full paper.

An electrical thermostat, by Dr. W. R. Whitney, consisted of mercury in a U tube. One arm of the tube contained ether, and the other air, at reduced pressure. One platinum wire was fused into the bottom of the tube and another above the mercury in the leg of the tube containing the ether. On the rise of the temperature the ether gas expanded much more rapidly than the air and forced down the mercury below the ether; a control electrical circuit through the platinum wires and the mercury is thus broken, and through it the heating circuit. Professor W. O. Atwater and E. B. Rosa described their apparatus for testing the law of conservation of energy

in the human body. The subject was confined in a room whose walls consisted of a layer of copper, outside of which were one layer of zinc and three layers of wood, with air spaces between. The temperature of the air spaces was kept the same as that of the inclosed room, by means of currents of air. The condition of uniformity of temperature was tested by many thermo-electric junctions in series, which were distributed over the surface as uniformly as possible. The average position of the galvanometer mirror was kept zero. A deflection of one millimeter on the scale corresponded to one one-hundredth of a degree Centigrade. The amount of heat evolved in the room was calculated from the corresponding mass and change of temperature of the air which was forced to enter and leave the room through pipes. Frequent analyses of the air were made to determine carbon-dioxide and water vapor. The average of the results indicated that the law of conservation of energy was true.

Professor E. B. Rosa read a paper by himself and Mr. A. W. Smith, on electrical resonance and dielectric hysteresis. The dielectric experimented on was used in the form of a condenser, which was placed in an electric circuit, in series with a coil whose self-inductance was just sufficient to bring the alternating current used into phase with the E. M. F. The power expended in the circuit was made up of two parts, one proportional to the resistance of the coil, and the other proportional to the equivalent resistance of the condenser. These quantities multiplied by the square of the current (virtual) gave the power expended.

Dr. Margaret E. Maltby presented an interesting paper on a method for the determination of the period of electrical oscillations and some applications of the same, which was based upon a new application of the Wheatstone bridge principle. The two

halves of the measuring instrument—an electrometer—serve as two arms of the bridge, and the other two contain a condenser joined to the electrometer needle and the two pairs of quadrants respectively. The relation that exists between these two, when there is no deflection, is a function of the rate of alternations in the current that passes through the system, viz:  $T = \pi CR$ , when  $T$  is the period of a single alternation,  $C$  the capacity and  $R$  the resistance. If  $C$  is known in electrostatic units and  $R$  in electromagnetic units,  $C/v^2$  should be substituted for  $C$  above, and it is then possible to solve for  $v$ . Other applications of the method are evident. See Wiedemann's *Annalen*, B. 61, H. 3, S. 553.

In a joint session of Sections A and B Professor G. W. Patterson, Jr., read a paper on the electro-static capacity of a two-wire cable, in which he deduced the formula

$$C = \frac{0.01206 K}{\log \frac{\sqrt{4RD + D^2} + D}{\sqrt{4RD + D^2} - D}},$$

when  $C$  is the capacity in microfarads per kilometer,  $K$  the dielectric constant of the medium,  $R$  the radius of each conductor and  $D$  the least distance between them. Common logarithms are used. Professor W. F. Durand explained an approximate method of treating differential equations, in which he integrated by summing up areas considered as trapezoids. By making the intervals small enough any degree of accuracy might be obtained. Professor Alexander Macfarlane explained a new method of solving certain differential equations that occur in mathematical physics. The method was applied to equations whose solutions involved exponential and sine functions. Mr. C. P. Steinmetz was on the program to read a paper on the screening effect of induced currents in solid magnetic bodies in an alternating field; but, much to

the regret of the Section, he was unable to be present.

GEORGE W. PATTERSON, JR.

UNIVERSITY OF MICHIGAN.

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*A NEW METHOD OF SYNCHRONIZING  
STRATA.\**

FOR nearly a century it has taxed stratigraphical geologists to the utmost to devise some rational and practical method by which the strata of the globe, the exposed sections of which are not visibly connected, can be brought into synchronous juxtaposition. Various schemes have from time to time been proposed, tried and abandoned. While it is a simple matter to correlate two rock outcrops which are not far away from each other, the difficulties rapidly increase with distance and by existing standards the determination of the exact equivalents finally become almost impossible.

It is the special province of geological correlation to establish a general chronologic sequence for rock successions more or less widely separated geographically. The main features of some of the more important standards of comparison that have been adopted or are being used may be briefly considered, their scope defined and their limitations noted. These methods fall into two main categories: (1) the strictly physical, and (2) the biological. Of these the latter have, for many years, been most widely followed. At the present time the former are beginning to assume much greater prominence than ever before.

So profound an influence have the organic remains entombed in the rocks had on correlation problems that it has only been very recently that the inherent weaknesses of this criterion has begun to be appreciated. The advantage of the physical

method over the biological is indicated by the remark made lately by McGee that "Nearly as much information concerning the geological history of the Atlantic slope has been obtained from the topographic configuration of the region within two years as was gathered from the sediments of the coastal plain and their contained fossils in two generations."

Indeed, for more than a score of years that branch of geology called stratigraphy has been practically at a standstill. Its methods are the same that were used 50 to 75 years ago. However, the science of geology as a whole has made gigantic strides. Within the last two decades several entirely new branches have sprung into existence. New and refined methods of working have been formulated. With all this activity going on about it, stratigraphy itself has been at last provided with new weapons of offense and defence, and is beginning to experience a revival that is surely destined to restore its old time prestige.

The scope of the purely physical criteria of correlation and of geological classification as set forth in late years appears to have been generally overlooked. Attention needs to be called only to a few of these. Irving and Van Hise have formulated admirable methods of correlation, in which organic remains are left entirely out of consideration. McGee and his colleagues have, by purely physical methods, attacked the unfossiliferous deposits of the coastal plain and then have applied the same methods successfully to the fossiliferous terranes. Davis and others have rejuvenated the old methods of stratigraphical continuity and lithological similarity, by making possible a system of correlation by geographic forms, and broad areas are now being geologically mapped by this method alone. All of these methods are more or less complex and not simple, but they demonstrate that newer and more natural ways are rapidly replac-

\* Abstracted from a paper read before the Academy of Sciences of St. Louis.